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Research Article

Physicochemical and nutritive quality characterization of developed banana stirred yogurt

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Abstract

Fruit yogurts are in a group of the milk products with increasing demand of nutritional intake. Present research aims to develop banana stirred yogurt using fresh and dried bananas and to assess its nutritional quality followed by analysis of shelf life and physicochemical parameters. This study was designed to combine the nutritive potential of banana with protein food source like yogurt to develop a nutrient loaded immune strengthening product. The samples of fruit yogurt were prepared and subjected to proximate analysis, mineral estimation, physicochemical and sensory analysis. The prepared samples were stored at 4°C for 15 days. The best results were obtained for T_2 the sample having osmotically solar dried banana chunks throughout the storage period. The significantly high amount of minerals such as Na, K and Ca (342 ± 10.26), (779 ± 31.16) and (897 ± 35.88) respectively, highest fat (3.76 ± 0.15) and protein content (4.71 ± 0.18) were obtained in the T_2 treatment. The physicochemical parameters such as acidity, viscosity and syneresis were significantly increased, while pH, total solids and lactose percentage showed significant decrease in all the samples. However, a progressive deterioration in taste, color, flavor, and texture of fruit yogurt was observed. To conclude, the yogurt having osmotically solar dried banana chunks showed the best quality up to 15 days of storage. Yogurt's nutritional value and flavor are enhanced by fruit, improving consumer acceptance and offers health advantages for the malnourished as well as vulnerable groups of the society.

Keywords: Osmotic; Physicochemical; Proximate; Syneresis; Viscosity

Introduction

Now-a-days food consumption is more based on nutrition and quality along with sensory and physical attributes. The requirement for better taste, reasonable price and complete nutrition is their priority. Value added food products for health-conscious consumers are gaining more importance [1]. The means to market the growth of the product is continuous modification and evaluation of the product to match consumer's expectations [2].

Consumption of goods with functional properties that shield people from stress and various illnesses has grown recently. Yogurt is particularly vital to the human diet since it contains a high amount of protein, essential fatty acids, and minerals like calcium and phosphorus. Utilizing probiotics in food products, such as Lactobacillus and Bifidobacterium, is one way to create functional foods [3, 4].

Different types of dairy products have been developed which are important source of nutrients such as yogurt, cheese and ice-

cream and also contains proteins, carbohydrates, vitamins and minerals. Dairy products have therapeutic properties and play a major role in reducing different ailments such as colon cancer, osteoporosis, hypertension, insulin resistance syndrome and obesity [5]. Depending upon consumer requirements milk can be transformed into different valuable products. Milk products are divided into two major types such as fermented and non-fermented. Process of fermentation includes severe biochemical changes in the product due to activity of microorganisms [6].

Yogurt is an oldest and well-liked fermented milk product used worldwide because of its nutritive and therapeutic values. It plays an important role in human nutrition, health maintaining, therapeutic and dietetic functions. Yogurt contains desirable organoleptic properties, uniform consistency and specific lactic flavor. In Pakistan, it is the second most consumed dairy product after fresh milk. People consume it as a beverage and food in Pakistan. Other than traditionally produced yogurt, many commercial brands of yogurt are available in the urban areas of Pakistan. Chemical composition of milk, type of flavors added and the nature of post incubation processing affect the quality of industrial yogurt [7].

Nutritional value of yogurt is much similar to milk from which it is made, but it can vary to some extent if other components such as fruits, cereals and sweetener components are added [8]. Banana is rich in amylose, vitamins, starch, dietary fiber, minerals and protein [9, 10]. Fresh as well as processed banana products are available in the market. Banana chips, banana puree, banana jam, canned banana slices and banana vinegar are commonly processed products of banana. Banana powder is also available to be used in desserts such as custards and ice creams. Banana puree is also used in the production of fruit flavored yogurt [11, 12].

Osmotic drying technique is among the oldest method of restoring food for longer span. The process involves ceasing of growing micro-organisms below a certain level of water content. Drying changes physical and structural conditions of the food. The process of drying brings about great change in banana; it reduces its weight and volume. This helps in packaging, storage and transportation of the product [13]. The taste of dried fruit is unique and nutritious and these are easy to handle during food formulation, preparation and transportation [14]. The loss of moisture content by dipping the food in concentrated aqueous solution of sugar or salt is defined as osmotic dehydration. The ultimate function of this process is to decrease the water content important for distribution and storage of food. It also minimizes the rate of chemical reaction on food [15]. Banana being a rich source of potassium and other nutrients can be added in the yogurt to improve its sensory and nutritional value hence imparting affirmative health benefits. Dried banana can be considered as an appropriate raw material for fruit yogurt due to its low moisture content. Therefore, present study was aimed to develop a value added yogurt using banana chunks and to assess its acceptability. Four homemade yogurt types were prepared using bananas and were evaluated for their proximate analysis, mineral analysis and physicochemical properties such as pH, acidity, syneresis, viscosity, total solids and lactose. The addition of fruit chunks during yogurt preparation may help to rectify some of the storage issues as well as increased nutritive value of the end product [16]. In Pakistan, bananas are popular and consumed in large amount by all age groups. So, this fruit was selected for the current research work.

Materials and Methods

The study was experimental in nature. It was conducted in Dairy, Bio-technology and Food Microbiology Labs, at National Institute of Food Science and Technology, University of Agriculture, Faisalabad.

Different types of Banana stirred yogurt were prepared using fresh and dried bananas and evaluated.

Preparation of yogurt

For yogurt preparation raw milk was procured from Dairy Farm, in cleaned and pre-sterilized container and stored at 4°C. Ripe bananas was purchased from local market whereas, dehydrated banana were osmotically dried after using appropriate pretreatments using electric dehydrator and solar tunnel dryer. Commercial yogurt was used for the inoculation of culture at the percentage of 2.5 %. Banana stirred yogurt samples were prepared after the addition of fresh and osmotically dried banana chunks. Yogurt prepared by using commercial culture was subsequently stored at 4°C for measuring various physicochemical characteristics. Plain yogurt was prepared by buffalo milk. Milk was heated to a boiling point to destroy the pathogenic organisms at 85°C for 10 minutes. It was then transferred to a container at 39 to 40 °C. 2.5% starter culture was added. Once the starter was completely mixed, it was incubated at 41^{0}C -43°C for 6 to 8 hours to complete the curd formation [17]. Fresh and osmotically dried bananas were cut into edible portion. Then they were added in yogurt with the ratio of 15 % fruit and 5% sugar. Samples of banana stirred yogurt were prepared with fresh bananas obtained from local market and the osmotically dried forms of banana, through electric and solar drying process (Table 1).

Table 1. Samples of prepared yogurt types

Sample code	Yogurt Type	Treatment
T_0	Plain yogurt	No fruit added
T_1	Blended Yogurt	Fresh banana
T_2	Blended Yogurt	Solar dried banana*
T_3	Blended Yogurt	Electrically dried banana**

*solar dried bananas treated with 20% sucrose, 3% citric acid and 0.4% potassium metabisulphite
**electrically dried bananas treated with 20% sucrose, 3% citric acid and 0.4% potassium metabisulphite

Proximate analysis

The proximate analysis of plain yogurt and fruit yogurt for moisture, protein and ash was done by using their respective methods given by [18]. Fat content was estimated by using Gerber method described by [19].

Mineral estimation

Minerals i.e. Sodium (Na) and Potassum (K) was determined by using flame photometer while Calcium (Ca), Iron (Fe), Copper (Cu), Zinc (Zn) and Manganese (Mn were determined by atomic absorption spectrophotometer by following the procedures as described in [18].

Physicochemical analysis of prepared yogurt

Physicochemical analysis was carried out at 0, 5, 10, 15 days. All readings were taken in triplicate to avoid error. Various physicochemical characteristics such as pH, acidity, syneresis, viscosity, total solids and lactose were determined by following standard test procedures.

Measurement of pH value

pH of yogurt was directly measured from digital pH meter [20]. Electrical digital type pH meter (WTW series pH-720) was used to determine pH of sample. pH meter was first calibrated using buffer solutions of pH 4 and 7. Yogurt about 10 mL was taken into beaker and adjusted to room temperature. Electrode of pH meter was immersed in samples and reading was taken after stabilization of pH meter.

Measurement of acidity level

Acidity was determined by direct titration method No. 947.05 [18]. A well-mixed sample homogenized yoghurt sample (10g) was taken in a china dish and then it was diluted with 10 mL distilled water, 2-3 drops of phenolphthalein solution was added as an indicator. After that it was

titrated against N/10 NaOH (Sodium Hydroxide) until a slight pink color appeared as an end point. The percent acidity (as lactic acid) was calculated as under:

Acidity%=0.009 × N/10 NaOH used (mL) × 100 / Weight of sample (g)

Measurement of syneresis value

Syneresis of the yogurt samples at different storage period was determined as 10gram yogurt sample was placed on a filter paper resting on the top of a funnel. After 10 min of drainage in vacuum condition, the quantity of remained yoghurt was weighted and syneresis was calculated as follow [21].

Free whey (g/100g) = Weight of initial sample - weight of sample after filtration × 100 / Weight of initial sample (g)

Measurement of viscosity

Viscosity of the samples was measured at 4°C and spindle No. 4 was used at rotation of 60 rpm using a Brookfield viscometer model number LVDVE 230, during storage. The readings were taken at 15th second. The measurements were taken in triplicate for every yogurt sample and the reading were expressed in centipoises [20].

Measurement of total solids

The percent residues called the total solids will be determined by drying the sample in hot air oven according to method described in [18]. A sample (5g) was taken in a clean dried weighed china dish. Then it was heated in a water bath for 15 minutes. It was then kept in a hot air oven for 3 hours at 100 º C and cooled in a desiccator for half an hour and weighed by following equation.

Total Solids % = Residue after drying (g) x 100 / Weight of sample (mL)

Measurement of lactose

Lactose was estimated by the method as given in [18]. A well-mixed and homogeneous representative sample (10 mL) was taken in a beaker. Then I added lead acetate solution. Filtered it and took the filtrate in another beaker. For titration, 10 mL sample was taken in a pipette and was added slowly into Erlynmeyer flask containing 10 mL Fehling's A and 10 mL Fehling' B solution. Blue color was appeared. Continuously boiled the solution until the final precipitate of blue color remained. Cool under running water.10mL potassium iodide and 10 mL sulphuric acid was added in flask. Two drops of starch solution were added as an indicator then titrated it against sodium thiosulphate solution until the end point was light pink. The volume of the sodium thiosulphate used was recorded. Volume of lactose solution was multiplied by a factor 0.65 (as 10 mL of Fehling solution = 0.65) to determine amount of lactose in yogurt.

Lactose (%) = 0.65 x equivalent weight obtained from lactose x 100 / Volume of sample used x 10

Sensory analysis

All the samples of prepared yogurt were sensorily evaluated with storage intervals of 0, 5, 10 and 15 days. The 9 points hedonic scale assessment was carried out by a panel of ten trained experts. They were research and teaching staff from department of Food Science and Technology. Panelists were provided with separate room equipped with proper light. Yogurt 100 mL was presented in transparent cups for evaluation and water was provided for rinsing mouth between samples. Yogurt samples were assessed for color, flavor, texture, taste and overall acceptability [22].

Results and Discussion

The obtained data were subjected to statistical analysis to ascertain the level of significance. Completely randomized design (CRD) was applied using Statistical Package (Statistix 8.1) outlined by [23]. The experiments were performed in triplicate and the results were reported as mean ± standard deviation and subjected to analysis of variance (ANOVA) in which P-value ≤ 0.05was taken as significant

The proximate analysis and mineral analysis of the yogurt treatments prepared are shown in the (Table 2 & 3). Data showed that The highest fat (3.76 ± 0.15) and protein content (4.71 ± 0.18) was found in T_2 among all the treatments while the moisture content was found to be highest in

controlled sample and ash content was in the range of (0.7 ± 0.03) to (0.84 ± 0.03). The results obtained are according to the findings of [24]. The significantly high amount of Na, K and Ca (342 ± 10.26), (779 ± 31.16) and (897 ± 35.88) were obtained in the T_2 treatment having the osmotically solar dried banana chunks as depicted in (Table 3) and the lowest amount of these minerals were obtained in the controlled treatment T_0 as that of Na (324 ± 12 .96), K (537± 16.11) and that of Ca was (834 ± 33.36). The results obtained are according to the values reported by [25].

Table 2. Proximate analysis of yogurt samples in percentage

Parameters	Treatments			
	T_0	T_1	T_2	T_3
Moisture %	84.47 ± 2.53^c	81.03 ± 2.83^b	79.05 ± 3.16^a	78.81 ± 2.76^b
Fat %	3.58 ± 0.12^a	3.6 ± 0.11^a	3.76 ± 0.15^a	3.4 ± 0.13^a
Ash %	0.7 ± 0.03^a	0.79 ± 0.03^a	0.87 ± 0.03^a	0.84 ± 0.03^a
Protein %	3.41 ± 0.14^b	4.65 ± 0.14^b	4.71 ± 0.18^a	4.24 ± 0.13^b

Values represent means ± SD. Means within a row without a common superscript differ significantly ($p< 0.05$)

Table 3. Mineral analysis of yogurt samples in mg/L

Minerals	Treatments			
	T_0	T_1	T_2	T_3
Na	$324 \pm 12 .96^a$	331 ± 13.24^a	342 ± 10.26^b	329 ± 9.87^b
K	537 ± 16.11^c	746 ± 22.38^b	779 ± 31.16^a	742 ± 22.26^b
Ca	834 ± 33.36^c	876 ± 35.04^a	897 ± 35.88^a	851 ± 34.04^b
Fe	1.872 ± 0.07^a	3.064 ± 0.12^a	2.674 ± 0.10^a	2.366 ± 0.09^a
Cu	0.497 ± 0.02^a	0.032 ± 0.001^b	0.038 ± 0.001^b	0.04 ± 0.001^b
Zn	0.172 ± 0.005^b	0.201 ± 0.01^a	0.325 ± 0.016^b	0.446 ± 0.017^b
Mn	0.62 ± 0.018^b	0.622 ± 0.03^a	0.482 ± 0.014^b	0.522 ± 0.024^b

Values represent means ± SD. Means within a row without a common superscript differ significantly ($p< 0.05$)

The pH of the yogurt samples was decreased as the storage time increased, the reason for this is the conversion of lactose into the production of lactic acid. At the initial stages, there was a slight decrease in pH from 0 to 5th day of storage whereas it decreased profoundly when storage reached 15th day. The results are according to the findings of [17, 26, 27]. In another study fermentation time was analyzed and found that pH value dropped at the end of 8^{th} and 12^{th} hours respectively. Lactose degradation and production of lactic acid was accelerated in the prepared yogurt which reduces the time for fermentation and ultimately drops the pH value [28].

The means values in the (Table 4) represent the acidity of all the treatments increases with the storage of time. The values of different treatments during 0 to 15 days were 0.83 ± 0.03 to 1.27 ± 0.05, 1.12 ± 0.04 to 1.28 ± 0.05, 1.13 ± 0.03 to 1.37 ± 0.06 and 1.22 ± 0.03 to 1.39 ± 0.05 for treatments To, T1, T2 and T_3 respectively. The results are according to the findings of [29-32]. There was an increase in syneresis for the control and banana stirred yogurt samples were observed. Between the initial and the final readings, reduction in syneresis was observed in T_3 which shows the significant effect of addition of osmotically solar dried banana chunks in yogurt so, the treatment T_3 showed the best results against reduction in yogurt syneresis These results are agreed with the study of [27, 33, 34]. The viscosity of controlled and banana stirred yogurt increased with the passage of storage time. The results of the

current study are in accordance with [35] they reported the increase in the viscosity of yogurt with the storage time. The mean values for total solids of controlled and banana stirred yogurt were not changed much with the passage of storage time which is presented in (Table 4). The results of the current study are according to the results explained by [36, 37]. Data revealed that the lactose decreased consistently throughout storage with the highest value at 0 day and lowest value was observed at 15th day of storage. These results are according to the findings of [38]. A significant decrease in the lactose concentration of yogurt has been observed with increased storage in refrigerator [39].

Table 4. Physicochemical Parameters of Prepared Yogurt treatments

Storage period (days)	T0	T1	T2	T3
pH				
0	4.62 ± 0.18^{a}	4.71 ± 0.14^{a}	4.73 ± 0.23^{a}	4.66 ± 0.14^{a}
5	4.23 ± 0.13^{b}	4.32 ± 0.12^{b}	4.45 ± 0.17^{b}	4 ± 0.12^{b}
10	4.07 ± 0.16^{b}	4.11 ± 0.16^{b}	3.99 ± 0.12^{b}	3.81 ± 0.15^{b}
15	3.89 ± 0.11^{b}	3.97 ± 0.15^{b}	3.86 ± 0.11^{b}	3.7 ± 0.14^{c}
Acidity				
0	0.83 ± 0.03^{g}	1.12 ± 0.04^{e}	1.13 ± 0.03^{e}	1.22 ± 0.03^{d}
5	1.01 ± 0.04^{f}	1.19 ± 0.03^{d}	1.18 ± 0.03^{d}	1.28 ± 0.05^{c}
10	1.2 ± 0.03^{d}	1.2 ± 0.04^{d}	1.29 ± 0.05^{c}	1.34 ± 0.05^{b}
15	1.27 ± 0.05^{c}	1.28 ± 0.05^{c}	1.37 ± 0.06^{ab}	1.39 ± 0.05^{a}
Syneresis				
0	2.88 ± 0.10^{g}	2.54 ± 0.10^{h}	1.83 ± 0.05^{k}	1.9 ± 0.05^{j}
5	3.95 ± 0.12^{e}	4.1 ± 0.18^{d}	2.2 ± 0.09^{i}	2.7 ± 0.10^{g}
10	5.23 ± 0.20^{c}	5.96 ± 0.23^{a}	3.1 ± 0.13^{f}	4.2 ± 0.16^{d}
15	6.18 ± 0.24^{a}	6.1 ± 0.21^{a}	4.1 ± 0.19^{d}	5.6 ± 0.22^{b}
Viscosity				
0	994 ± 29.8^{i}	1155 ±40.4^{g}	1232 ± 36.9^{f}	1110 ±33.3^{h}
5	1354.2 ±40.6^{e}	1479.1 ±44.3^{d}	1522.1±45.6^{d}	1260 ± 37.8^{f}
10	1463.1± 43.8^{d}	1566.7±47.0^{d}	1744 ± 61.0^{c}	1510 ± 45.3^{d}
15	1725 ± 51.7^{c}	1847 ± 55.4^{b}	1911.2 ±76.4^{a}	1869 ± 56.0^{b}
Total Solids				
0	14.42 ± 0.43^{d}	20.08 ± 0.80^{a}	26.2 ± 0.91^{a}	23.11 ± 0.69^{b}
5	14.3 ± 0.57^{c}	20.02 ± 0.60^{b}	26.11 ± 0.78^{a}	23.0 ± 0.69^{b}
10	13.89 ± 0.41^{d}	19.78 ± 0.59^{c}	25.99 ± 0.77^{a}	22.84 ± 0.68^{b}
15	13.71 ± 0.54^{c}	19.22 ± 0.76^{a}	25.64 ± 0.99^{a}	22.69 ± 0.90^{a}
Lactose				
0	4.21 ± 0.16^{e}	4.67 ± 0.18^{c}	5.81 ± 0.23^{a}	5.56 ± 0.16^{b}
5	3.88 ± 0.13^{f}	3.96 ± 0.13^{f}	4.45 ± 0.15^{d}	4.33 ± 0.12^{d}
10	3.67 ± 0.12^{fg}	3.49 ± 0.12^{g}	3.87 ± 0.15^{f}	3.75 ± 0.15^{fg}
15	3.46 ± 0.13^{g}	3.26 ± 0.13^{h}	3.68 ± 0.14^{fg}	3.51 ± 0.14^{g}

Values represent means ± SD. Means within a column without a common superscript differ significantly ($p< 0.05$)

The (Table 5) shows the scores for sensory attributes including color, flavor, texture, taste and overall acceptability, acquired by different treatments of yogurt throughout the storage period. The liking score of the yogurts differed significantly between treatments for overall acceptability. Regarding color, flavor, texture, and taste, yogurt having osmotically solar dried banana chunks had higher liking scores

than other yogurt treatments. Besides, the hedonic ratings of taste/ flavor of the yogurt having osmotically solar dried banana chunks were significantly higher than the fresh and electric dried banana chunks yogurt treatments. The flavor received the highest score at 0 day and continues to decline throughout storage, while the lowest scores were observed at 15 day for all yogurt samples. The flavor of the yogurt having osmotically solar dried banana chunks was appreciated by judges throughout the storage period. The results are agreement with the findings of **[35, 40]** they found a decrease in flavor of yogurt during storage. Scores indicated a significant effect of storage on color. During storage color of yogurt was not much affected by the addition of osmotically dried banana chunks, similar results were reported by **[35]**.

The mean scores for the texture and taste of yogurt decreased from 0 to 15 days of storage. The results are also in accordance with the results of **[32]**, in which they reported a decrease in taste and texture of yogurts during storage time. Statistical data represents that during storage overall acceptability of yogurt was found to be decrease with the passage of time. The highest score (7.69 ± 0.33) was given to T_2 the yogurt having osmotically solar dried banana chunks. According to statistical analysis of variance it can be concluded that the effect of storage time on treatments was significant. Similar results are reported by **[41]** and found that there is change in the overall acceptability of the product during storage.

Table 5. Sensory Characteristics of Prepared Yogurt treatments

Storage period (days)	T_0	T_1	T_2	T_3
Color				
0	7.5 ± 0.22^{a}	7.3 ± 0.22^{a}	7.41 ± 0.29^{a}	7.22 ± 0.28^{a}
5	7.39 ± 0.29^{a}	5.8 ± 0.27^{d}	7.36 ± 0.22^{a}	6.99 ± 0.28^{a}
10	7.21 ± 0.28^{a}	4.7 ± 0.19^{e}	7.25 ± 0.29^{a}	6.56 ± 0.27^{b}
15	6.9 ± 0.27^{a}	4.1 ± 0.24^{f}	7.1 ± 0.28^{a}	6.09 ± 0.26^{c}
Flavor				
0	7.4 ± 0.22^{a}	7.1 ± 0.21^{a}	7.3 ± 0.21^{a}	6.9± 0.27^{a}
5	7.0 ± 0.2^{a}	6.6 ± 0.26^{a}	7.11 ± 0.28^{a}	6.54 ± 0.26^{a}
10	6.82 ± 0.20^{a}	5.87 ± 0.18^{c}	6.88 ± 0.20^{a}	6.1 ± 0.25^{b}
15	6.66 ± 0.19^{a}	4.23 ± 0.18^{e}	6.74 ± 0.20^{a}	5.3 ± 0.18^{d}
Texture				
0	7.6 ± 0.29^{a}	7.1 ± 0.28^{b}	7.56 ± 0.29^{a}	6.84 ± 0.27^{b}
5	7.26 ± 0.21^{b}	6.49 ± 0.19^{c}	7.18 ± 0.28^{b}	6.51 ± 0.26^{c}
10	6.9 ± 0.21^{b}	6.25 ± 0.18^{c}	7.11 ± 0.21^{b}	6.41 ± 0.19^{c}
15	6.77 ± 0.28^{b}	5.65 ± 0.18^{d}	6.98 ± 0.27^{b}	6.33 ± 0.25^{c}
Taste				
0	7.45 ± 0.22^{a}	7.3 ± 0.21^{a}	7.49 ± 0.29^{a}	6.9 ± 0.28^{a}
5	7.0 ± 0.28^{a}	6.63 ± 0.26^{a}	7.11 ± 0.28^{a}	6.64 ± 0.26^{a}
10	6.82 ± 0.27^{a}	5.9 ± 0.24^{c}	6.88 ± 0.27^{a}	6.43 ± 0.19^{ab}
15	6.4 ± 0.19^{ab}	4.9 ± 0.18^{d}	6.74 ± 0.20^{a}	6.1 ± 0.18^{b}
Overall acceptability				
0	7.4 ± 0.27^{b}	7.45 ± 0.25^{b}	7.69 ± 0.33^{a}	7.1 ± 0.28^{b}
5	7.39 ± 0.29^{b}	6.9 ± 0.27^{b}	7.36 ± 0.33^{b}	7.05 ± 0.21^{b}
10	7.21 ± 0.28^{b}	5.64 ± 0.26^{c}	7.25 ± 0.32^{b}	6.88 ± 0.27^{b}
15	6.9 ± 0.33^{b}	4.77 ± 0.27^{d}	7.15 ± 0.32^{b}	6.69 ± 0.26^{b}

Values represent means ± SD. Means within a column without a common superscript differ significantly ($p< 0.05$)

Conclusion

The physicochemical and organoleptic analysis concluded that the highest score was obtained by T_2 the yogurt having osmotically solar dried banana chunks. Yogurt containing osmotically electric dried banana chunks T_3 was graded after control treatment T_0 whereas, T_1 yogurt containing fresh banana chunks was ranked last. There was a decline in the overall acceptability of all treatments including flavor, texture, color, appearance during storage. Hence, it was concluded from all the analysis that the yogurt having solar dried banana gave the best results and got the maximum scores for organoleptic evaluation, and remained the best during the whole storage period.

Authors' contributions

Conceived and designed the experiments: Z Tariq, N Sahar & M Tariq, Performed the experiments: Z Tariq, M Ijaz, R Fatima, K Rizvi, Analyzed the data: N Sahar, Z Rasheed, M Tariq, Contributed materials/ analysis/ tools: Z Tariq, HM Dar & K Rizvi, Wrote the paper: Z Tariq, M Ijaz & R Fatima.

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